Increased Methane Emissions for Mechanical Miners Working in Burnt Coal

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ABSTRACT

An intensive research programme has quantified the methane conditions around mechanical miners in production conditions. Methane seam gas contents show an increase of up to 26 times when mining burnt coal compared with normal increase in emission rates.

Coal seam methane contents at the face increased from 1 m^3/t to 6 m^3/t in one section, and from 0.1 m^3/t to 2.6 m^3/t in another. Emission rates from burnt coal were as high as 300 l/t/min as it was mined. These increases in content and emission occur immediately after cutting into the burnt coal.

Methane concentrations of 3% were recorded behind the cutting drum of a continuous miner working in burnt coal, with other peak concentrations of 2.5% and 2.7%. Concentrations above the legislated 1.4% were maintained for 52 percent of actual coal cutting time, and above 2% methane for 23 percent of cutting time.

Highest methane was generally detected on the return side of the continuous miners, but did also cover the entire front area, at least to the back of the cutting drum. Methane sensors positioned in the operator's cab were ineffective in detecting the high methane concentrations close to the face.

KEYWORDS

Methane, Continuous Miners, Roadheaders, Burnt Coal and Gas Contents

INTRODUCTION

The hazard of increased methane in burnt or devolatilised coal has long been recognised. However the actual increase in methane or methane emissions has been difficult to quantify.

Continuous miners and roadheaders are widely used in South African underground coal mining, and are attributed with the rise in frictional ignitions of methane over the last 20 years (Phillips, 1996) with the increased methane emissions in burnt coal, this risk of a frictional ignition also increases.

Methane problems at the Secunda Collieries have historically been associated with dykes, intrusions, and burnt coal (Van Der Merwe, 1995) and Sasol Coal has recognised the need for further research in this area to improve safety and minimise the risk of frictional ignitions.

Part of this research has been to quantify methane conditions around continuous miners, which has involved extensive on-board monitoring of methane concentrations, as well as coal sample analysis for methane content and release rate. This has again highlighted the problems of burnt coal, but has also been able to quantify the conditions and indicate the areas that need attention.

Methane conditions are presented here for actual operating continuous miners, specifically the increased levels for burnt coal. The basic monitoring techniques are described. This work forms only part of a larger methane safety research programme being undertaken by Itasca Africa for Sasol, covering continuous miners, goafs and face methane conditions.

MONITORING PROCEDURES

Methane Concentrations

A continuous miner (CM) is equipped with up to ten methanometers, each with data logging facilities. These methanometers are completely independent of the CM, its power supply and any standard methanometers that may be installed.

Two methanometer types are used, one with a built-in pump and one without. Those with pumps are used to sample from the areas most likely to result in damaged or lost instrumentation, such as immediately behind the drum or underneath the boom. Small diameter tubes are extended from these positions to the methanometers and the sample collected by pumping over the sensors. Those without pumps are installed in protective cases directly where the result is required, such as on the side of the boom or in the operator's cabin.

Methane Contents and Emission

To support the on-board concentration results, newly cut coal samples were collected from shuttle cars, immediately sealed in gas tight canisters and the methane being emitted measured directly by water displacement. The total gas emitted determined the gas content of the coal, and the initial rate of release for the first few minutes determined the release rate. This method as part of the Methane Rating method for continuous miners (Cook, 1997) is implemented across the Sasol collieries.

Ventilation

The research work was to determine normal operating conditions so no adjustments or improvements were made to the ventilation in any of the sections prior to, or during, the tests. The ventilation described in the figures or text was as installed by the section workforce.

RESULTS

Results are presented as plots of methane concentrations against time, downloaded from the recording methanometers. They show all or part of the monitored shift, so are not only for coal cutting. Each cutting cycle is generally recognised by an increase in methane, and the times are indicated in the text.

Results are given for two sections, reported as 1 and 2, and these are at two different collieries. Those for Section 1 are from two shifts and two different areas in the section, one in burnt coal the other in normal. Those for Section 2 are from one shift, with the burnt and normal coal close together in the immediate vicinity of a dyke. The normal coal was mined in the barrier pillar.

Also shown are the approximate positions of the CM's during the tests or at the times of peak methane concentrations.

Methane Concentrations

Figure 1 shows methane concentrations up to 0.7 % for a CM in normal coal, Section 1. The actual coal cutting cycles are at times 08h40 - 09h05, and 10h14 - 10h50. In both cases there is an increase in methane concentrations associated with the coal cutting, but these return to the lower range, around 0.2%, when cutting stops.

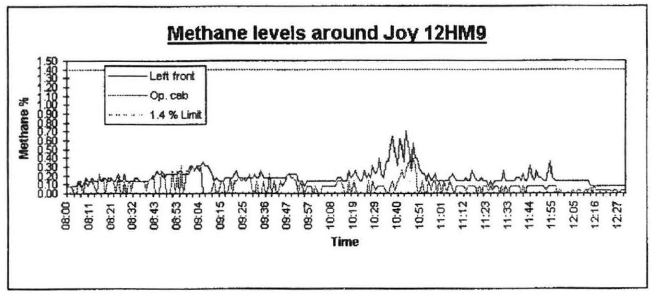

Figure 1. Methane concentrations, normal coal, Section 1.

Figure 2 shows methane concentrations up to 2.5 % for the same CM cutting burnt coal also in Section 1. There are three main cutting cycles recorded, 09h12 - 09h40, 10h26 - 10h58 and 12h24 - 12h34. All of these show increased methane levels, but with the levels getting progressively higher in each period as the CM advanced.

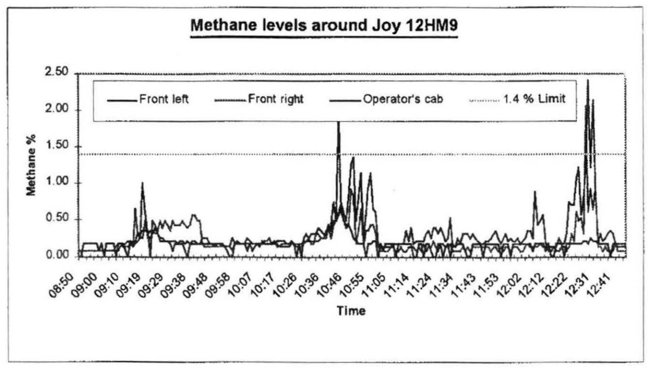

Figure 2. Methane concentrations, burnt coal, Section 2.

The increase in methane at 12h20, to 1.3 %, was due to sweeping coal from the floor, showing not all methane was liberated from the face.

Figure 3 shows the approximate positions of the CM during the cutting cycles in burnt coal. The positions and sequence are numbered 1 to 5. The highest methane, at 2.5 % was at position 5, and not when confined in the first lift as is commonly seen. At this time a second jet fan had been installed at position A "to reduce the dust". It is possible this contributed to the higher methane by forcing against the return from the scrubber.

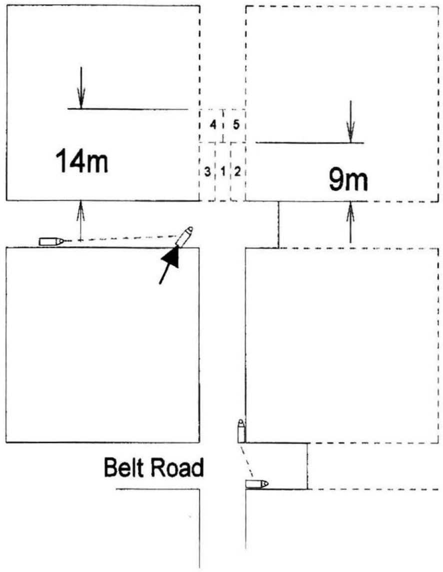

Figure 3. Cutting positions in burnt coal, Section 1.

Figure 4 shows methane concentrations up to 2.7% for burnt coal in Section 2. There are three cutting cycles plotted: 10h15 -11h15, 13h20 - 13h35 and 14h14 - 14h40. The first of these was in normal coal, the other two in burnt, and the difference in methane concentrations is very obvious. In normal coal the peak level was 0.6 %, but in burnt coal this increased immediately cutting started to 2 %, and later to 2.7 %.

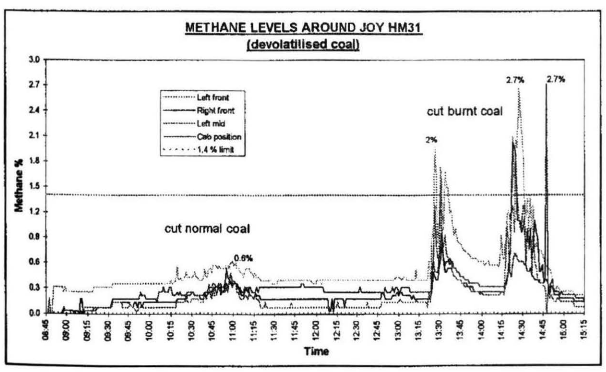

Figure 4. Methane concentrations, Section 2.

Figure 5 shows methane levels recorded in the same test, but of a sample pumped from immediately behind the cutting drum. These show a peak of 3 % at 13h34. This coincides with a general increase in all sensor readings at the same time (seen in Figure 4), so the methane was not now confined to the immediate face, but extended back at least over the full width of the drum.

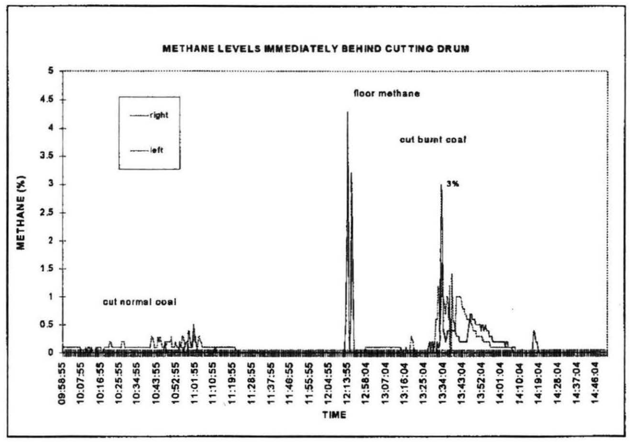

Figure 5. Methane concentrations behind drum, Section 2.

Figure 6 shows the position of the CM when cutting burnt coal in Section 2. It had progressed through a dyke, and the face had already been exposed for a considerable time before the CM began cutting. It was in the first lift from a square face, approximately 7 m from the end of the ventilation ducting.

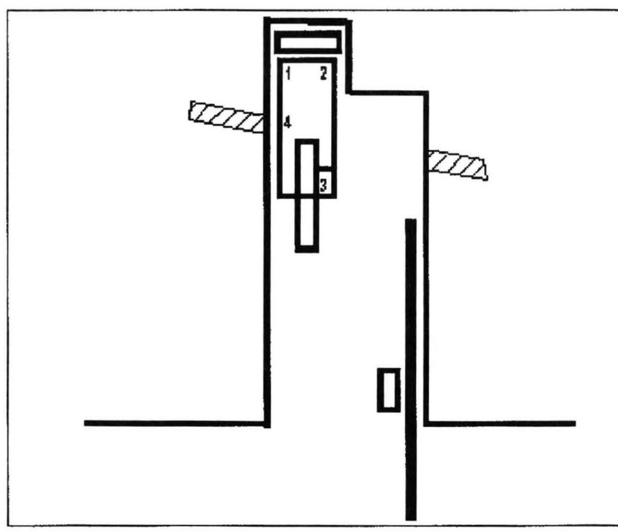

Figure 6. Cutting positions in burnt coal, Section 2.

Due to the expected high methane emissions a jet fan and ducting were being used in parallel to provide ventilation.

Methane Contents and Emission

Table 1 shows the gas contents of, and initial emission rates from, the newly mined shuttle car coal samples. The contents are cubic metres of gas per tonne of coal (m^3/t), and the emission rates are in litres per tonne per minute (l/t/min).

Table 1. Methane contents and emission rates.

sample (section, coal, position)	methane content (m^3/t)	emission rate (l/t/min)
1, burnt	6	300
1, normal	1	n.a.
2, burnt, 1 m from dyke	2.6	90
2, burnt 2 m from dyke	2.3	136
2, normal, 5 m from dyke	0.1	12
2, normal 1, barrier pillar	0.4	16
2, normal 2, barrier pillar	0.4	8

Burnt coal samples have contents up to 6 m^3/t, and release rates of 300 l/t/min. These were recorded in Section 1, where the normal coal gave a content of 1 m^3/t, unfortunately the release rate is not available. Results for Section 2 are no less dramatic, with content increases from 0,1 m^3/t to 2,6 m^3/t, and release rates from 8 l/t/min to 136 l/t/min.

DISCUSSION

Methane Concentrations

The methane concentrations around the CM's increased immediately upon mining into burnt coal, and remained at higher levels for periods of several minutes, or virtually the full extent of the mining time.

In Section 2 concentrations above 1.4% methane were maintained in burnt coal for 18 minutes and 26 minutes respectively during the two cutting periods. This amounts to 52% of the total coal cutting time. Methane concentrations above 2 % were maintained for 23% of the cutting time. In the second period, from 14h14 - 14h40 this level was actually maintained for 38% of the time.

Although the methane concentrations appear high, they are not unique to the test site collieries, or to the Secunda coalfield, or to burnt coal. Similar levels have been recorded and reported previously for CM's working at other collieries in normal coal (Cook 1995, Van Zyl, 1996). It is therefore a reasonable assumption that all continuous miners are exposed to methane concentrations above 1.4%, possibly on a regular basis. These exposures may be only short term peaks, or for considerable periods, but it would appear that standard on-board methanometers do not always detect them.

Methane Contents and Emission

The increases in methane content and release are very significant, and happen immediately the burnt coal is encountered. Although the seam gas contents may seem low compared to some values quoted, particularly from other countries, it is the relative increase that is important. The contents in Section 2 changed by 26 times in matter of one or two shears.

The samples for Section 2 were taken 3 m apart, the burnt sample at 2 m and the normal at 5 m through the dyke. As these were taken mining away from the dyke, and not towards it, and the face had stood exposed before mining, some degassing would already have taken place. Conditions approaching a dyke may have shown even greater increases.

Methanometer Positions

In all the tests a methanometer was installed in the operator's cab. This generally does not register the high methane contents recorded at the front of the CM. One peak of 2.7 % did occur at the end of the Section 2 test possibly due to a sudden change of ventilation, such as the scrubber being switched off.

CONCLUSIONS

Methane concentrations around continuous miners increased significantly and immediately when mining into burnt coal.

Peak concentrations of 3% occurred, with other peaks of 2.5% and 2.7%.

Levels above the permitted 1.4% were maintained for several minutes during both tests. In Section 2 this amounted to 52 per cent of the cutting time, and concentrations remained above 2% for 23 percent of the cutting time.

Methane content for normal coal ranged from 0.1 m^3/t to 1 m^3/t, and these increased to 2.3 m^3/t to 6 m^3/t for burnt coal. Emission rates were 8 - 16 l/t/min for normal coal, increasing to 90 - 300 l/t/min for burnt.

Although ventilation at least complied with guidelines, insufficient volumes reached the immediate face area to dilute the methane being emitted to below 1.4 %

The CM's tested were both equipped with standard on-board methane detection and alarm systems. At no time did the systems alarm.

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